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Report on variable level forecasts on the octagon area

by

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FH33

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Nguyen Ngoc Anh

Report on variable level forecasts on the octagon area

1. Introduction

The 10-level model was converted to the variable level one so that forecasts could be obtained from experiments with different vertical distributions of pressure levels. Both the 10-level and the variable level model used the split semi-implicit integration scheme described by Burridge (1975) and were run with a time step of 15 minutes. The initial data for the variable level version was obtained from the initialised 10-level data using orthogonal polynomial interpolation described by Forsythe (1957). A diagnostic program was written to compute RMS errors at 10 pressure levels between 100 mb and 1000 mb at intervals of 100 mb.

From July to September 1976 6 day forecasts on the octagon area were obtained from variable level experiments for a particular synoptic situation on 20/6/1976. The forecasts were assessed subjectively and the numerical results were used for the purpose of comparison between the 10-level and variable level model performance.

2. Experiments

Extra pressure levels were put in the middle of the basic 10-level 100 mb layer from the top of the atmospheric column in Experiment A and from the middle of the atmospheric column in Experiment B. Experiment C was aimed for the problem of high concentration of pressure levels in the layer of jet streams.

At the time of this report being done progress is still being made so that experiments on the surface boundary layer and aspects about a model containing less than 10 levels can be considered.

Table A provides a list of the successful runs of the experiments described above.

3. Results

Subjectively the variable level surface forecasts were rather disappointing since they generally produced the same gross errors as the 10-level surface forecasts. An illustrated example is given in Figs 1-4 which show the initial analysis at 12z 20/6/76, the final analysis at 12z 26/6/76 and the 10-level and run A17 6 day forecasts. The 10-level forecast failed to predict the existence of the depression over the Pacific Ocean and so did all variable level forecasts. Minor differences

between the 10-level and the variable level forecasts resulted in the fact that the variable level forecasts usually described lows and highs slightly better or slightly worse than the 10-level forecasts. There was no significantly improved synoptic development to be recorded.

Tables B.1-10 show RMS errors for all forecasts at 10 pressure levels between 100 mb and 1000 mb at intervals of 100 mb over the complete octagon area and a 20 x 20 area surrounding the British Isles. According to White (1976) one of the disadvantages of the semi-implicit scheme is its tendency to produce intense cold pools and since the cold pools arose mainly in central Asia, in polar regions or in Canada, the 20 x 20 area was largely uncontaminated by them. Tables C.1-10 show RMS error difference between the 10-level and variable level forecasts for each of 10 pressure levels.

Basically all variable level forecasts did not perform well in the lowest layers of the troposphere. Since there were no experiments on the surface boundary layer no preliminary conclusion on the performance of the variable level model on the lowest tropospheric layers could be made. Considering the jet steam layers, however, the variable level model produced forecasts with better accuracy than the 10-level model. This feature is well illustrated in numerical results given by Experiment A, which was designed to improve the upper layer forecasts. Figs 5-7 provide an opportunity to make a 6 day 200mb height field forecast comparison for run A17. The patterns suggest that there was no significantly improved synoptic development although the RMS error of run A17 was much less than the 10-level one. Experiment B, which was designed to improve the middle troposphere forecast, did show some slight improvement in the considered layer. In Experiment C the high concentration of pressure levels about the 300 mb level was established so that the 300 mb forecasts could be improved. Its numerical results indeed proved the above suggestion.

An example of RMS error distribution with pressure levels and with forecast time is illustrated in Fig 8 using the numerical results of run A17.

4. Conclusion

It can be concluded that the vertical distribution of pressure levels is able

to have an effect on the quality of forecasts.

It would be desirable to use initialised variable level data for performing experiments. Future experiments can be aimed at the surface boundary layer to measure the quality of surface forecasts. Considering the problem of CPU time, it is also useful to use less than 10 levels in the vertical to see whether forecast accuracy is maintained in comparison with the 10-level performance.

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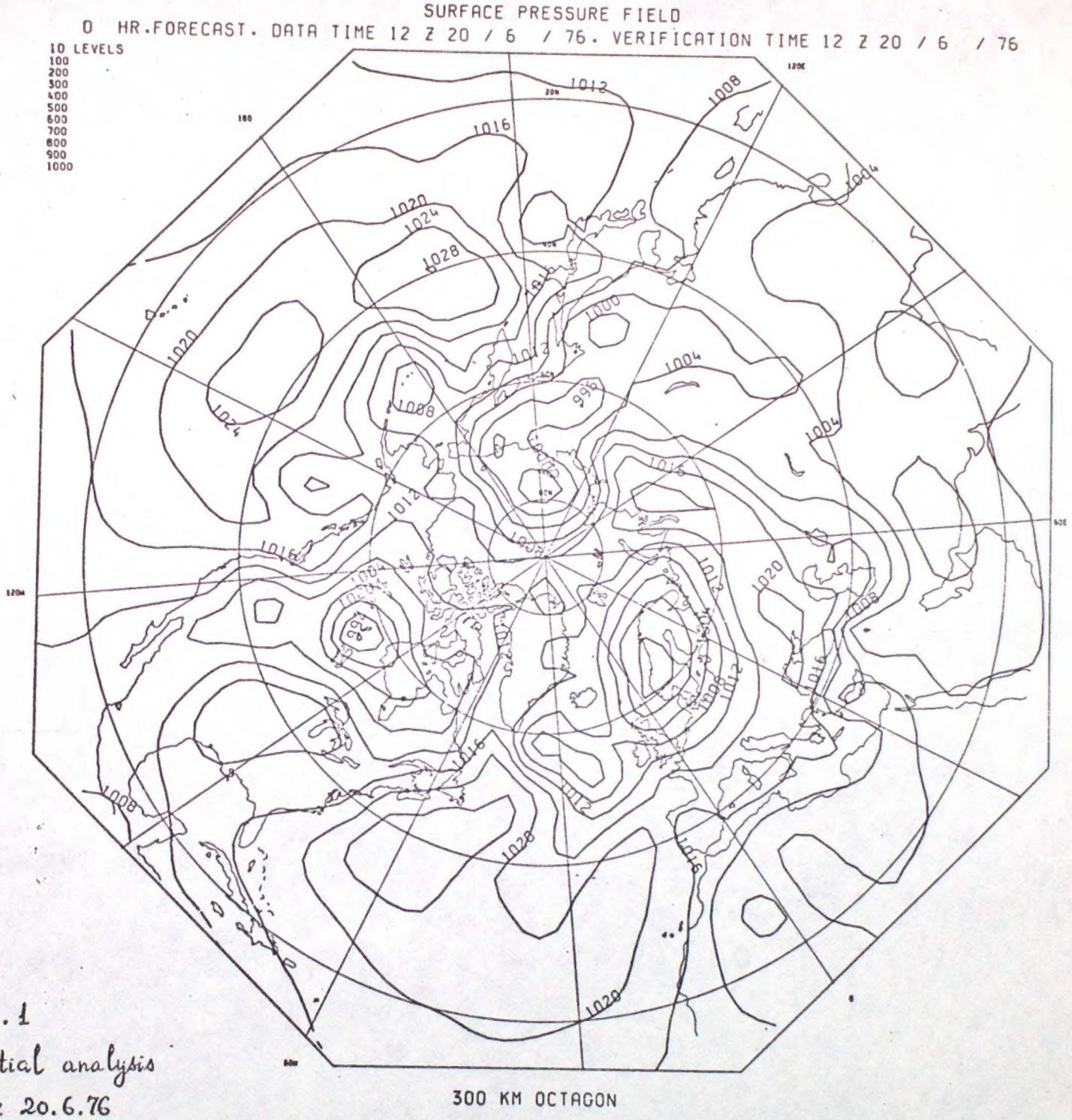


300 KM OCTAGON

Fig. 1
Initial analysis
12z 20.6.76

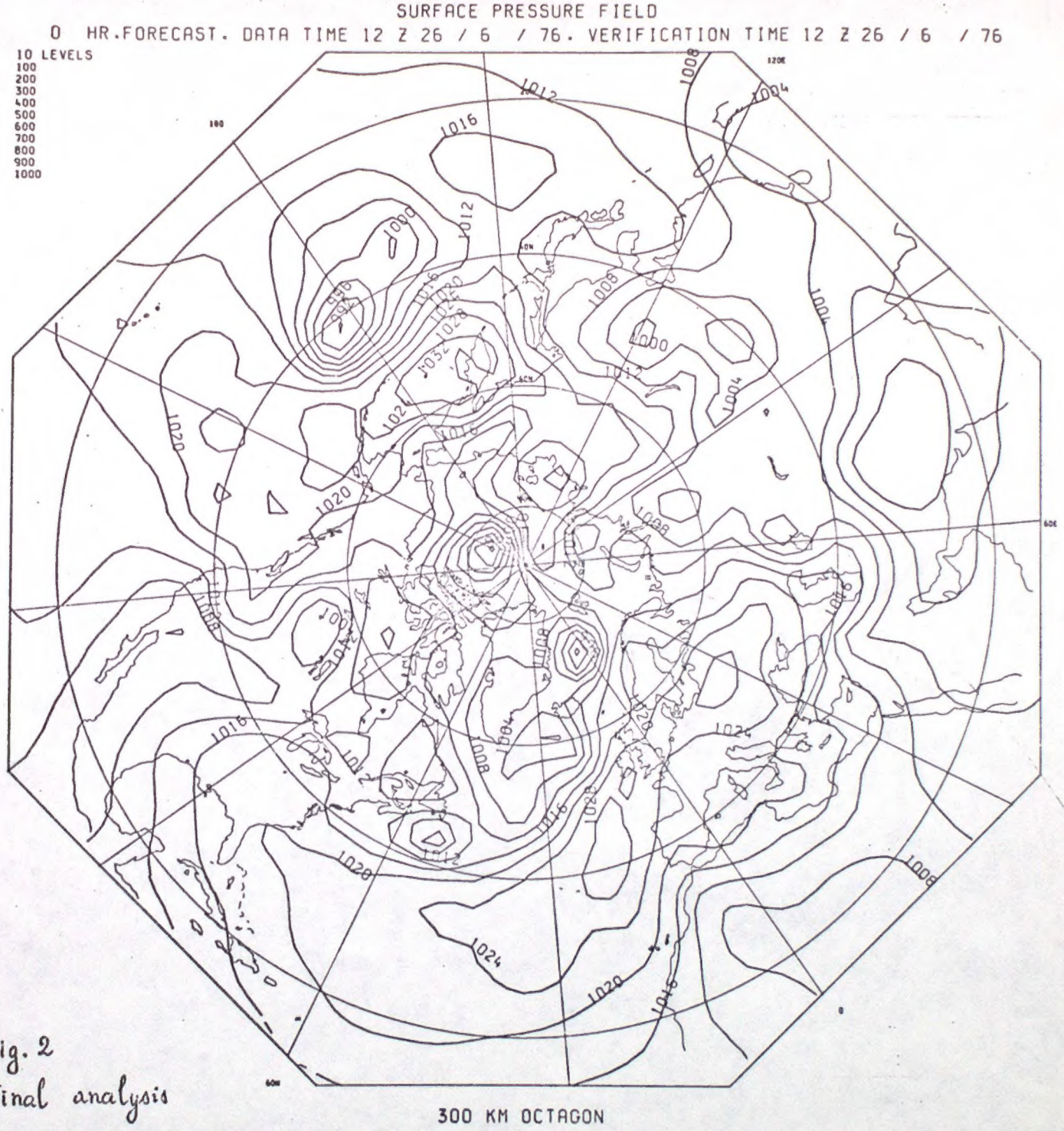


Fig. 2
Final analysis
12z 26.6.76

SURFACE PRESSURE FIELD

144HR.FORECAST. DATA TIME 12 Z 20 / 6 / 76. VERIFICATION TIME 12 Z 26 / 6 / 76

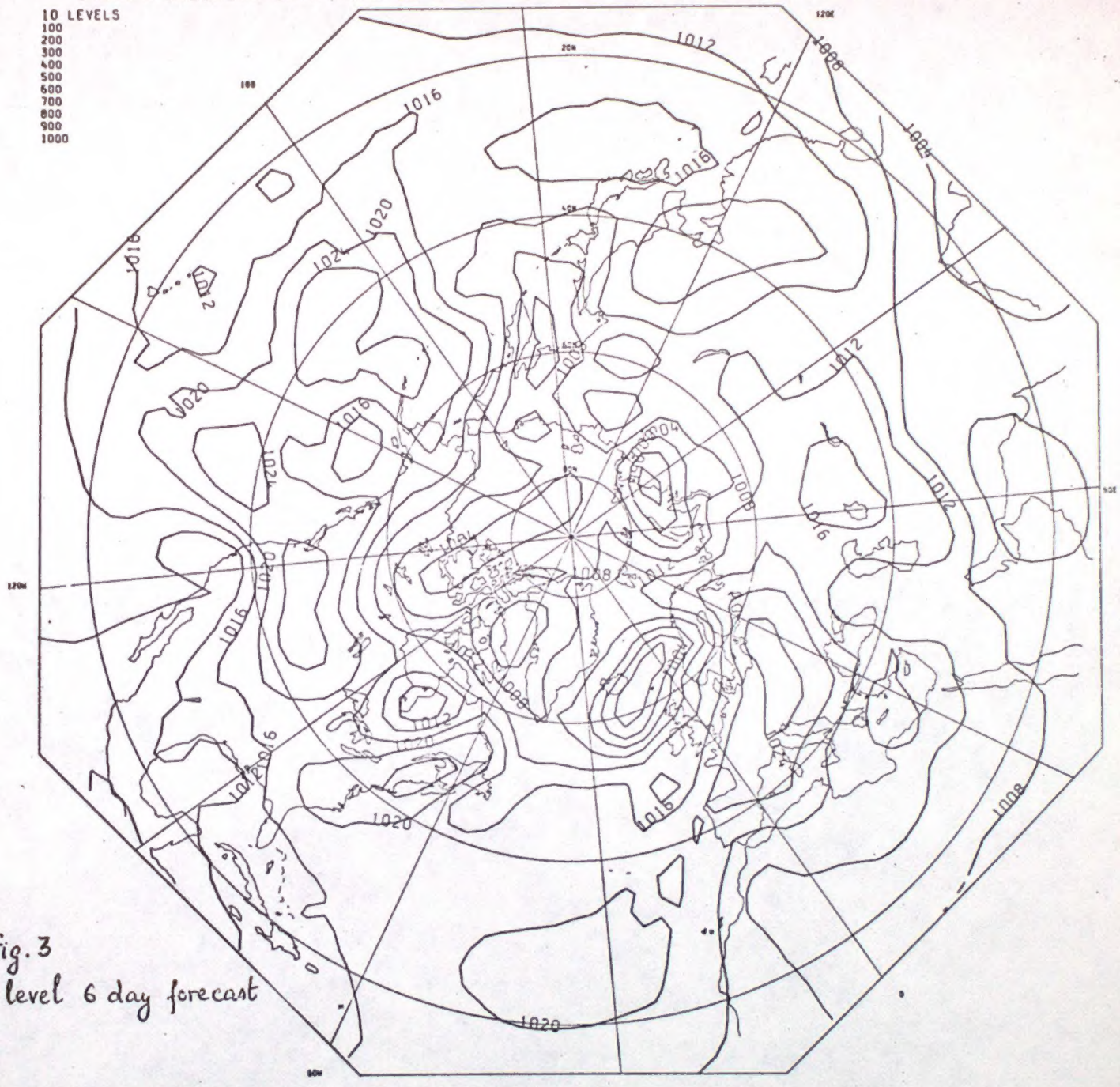
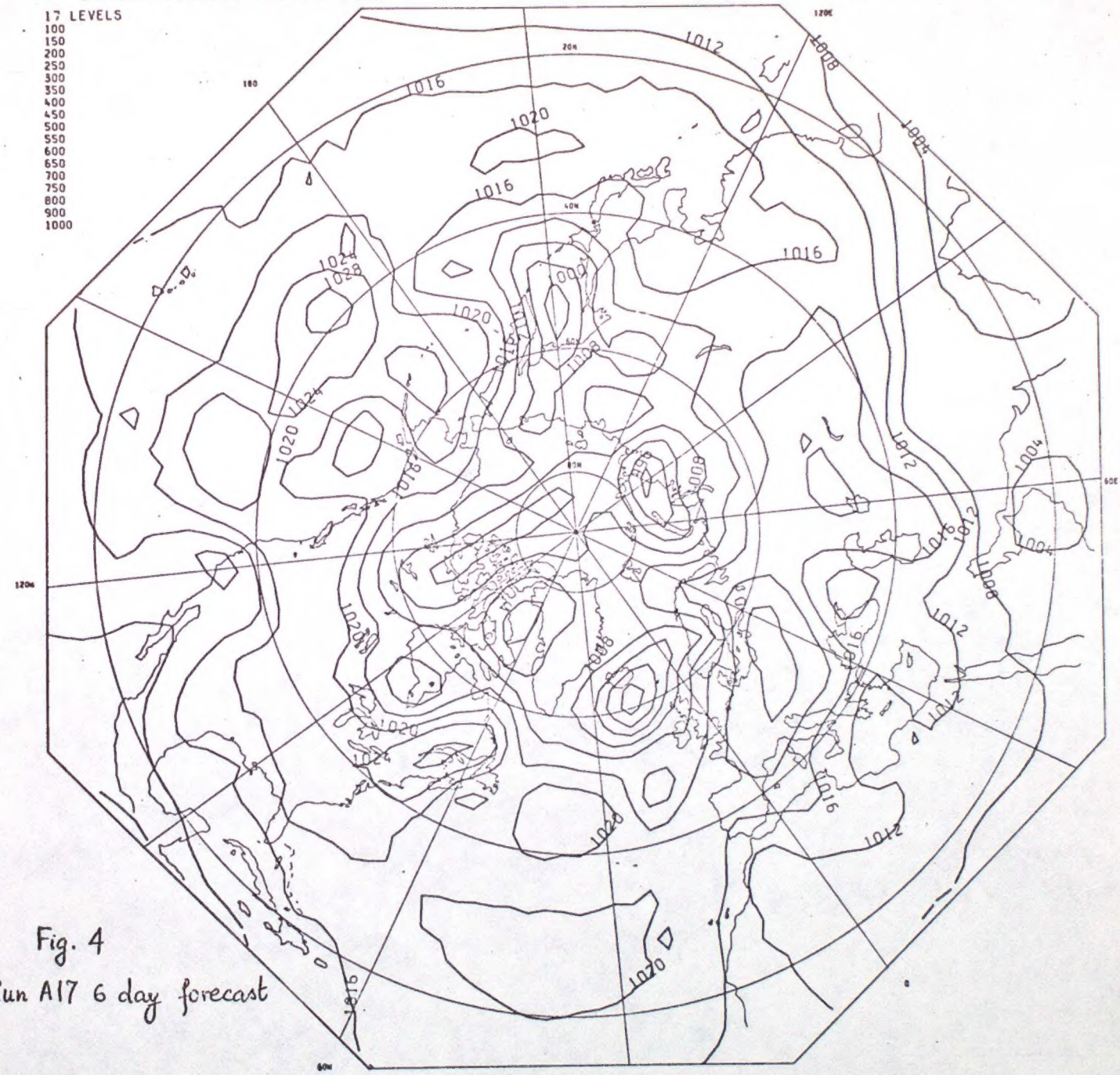


Fig. 3
10_level 6 day forecast

300 KM OCTAGON

SURFACE PRESSURE FIELD

144HR.FORECAST. DATA TIME 12 Z 20 / 6 / 76. VERIFICATION TIME 12 Z 26 / 6 / 76



300 KM OCTAGON

Fig. 4

Run A17 6 day forecast

200 MB HEIGHT FIELD

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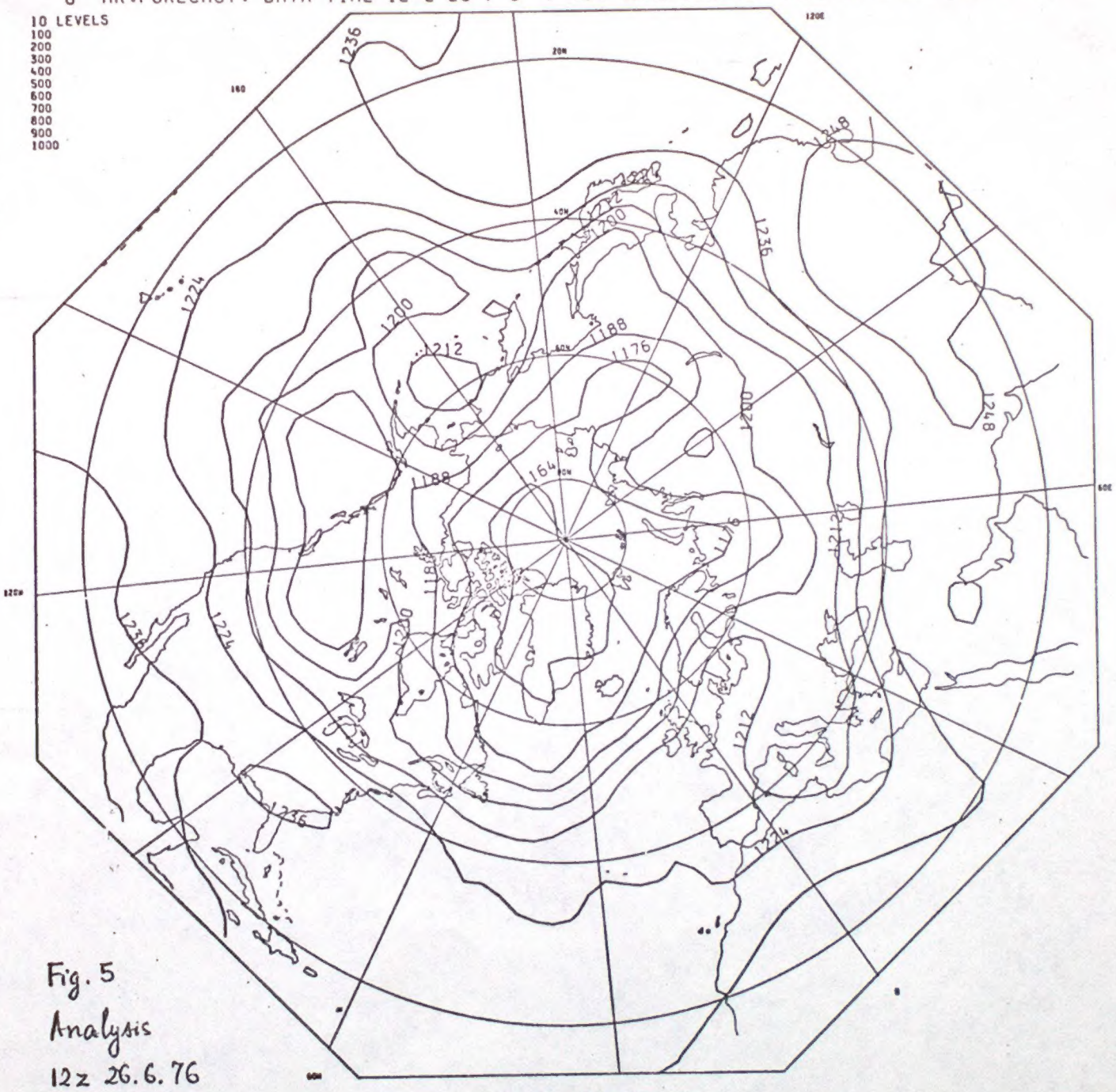


Fig. 5
Analysis
12z 26.6.76

300 KM OCTAGON

200 MB HEIGHT FIELD

144HR.FORECAST. DATA TIME 12 Z 20 / 6 / 76. VERIFICATION TIME 12 Z 26 / 6 / 76

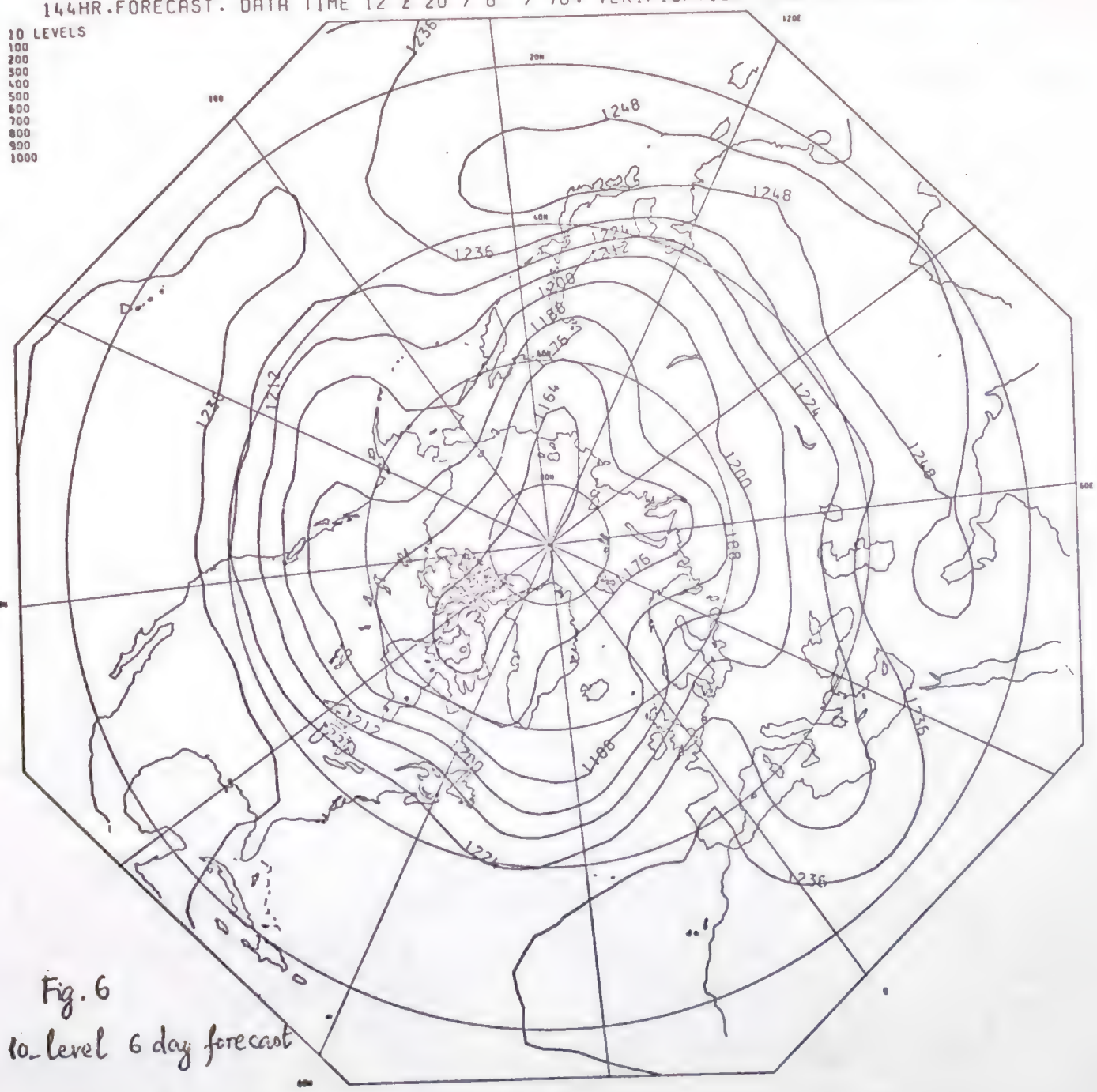


Fig. 6
10_level 6 day forecast

300 KM OCTAGON

200 MB HEIGHT FIELD

144HR.FORECAST. DATA TIME 12 Z 20 / 6 / 76. VERIFICATION TIME 12 Z 26 / 6 / 76

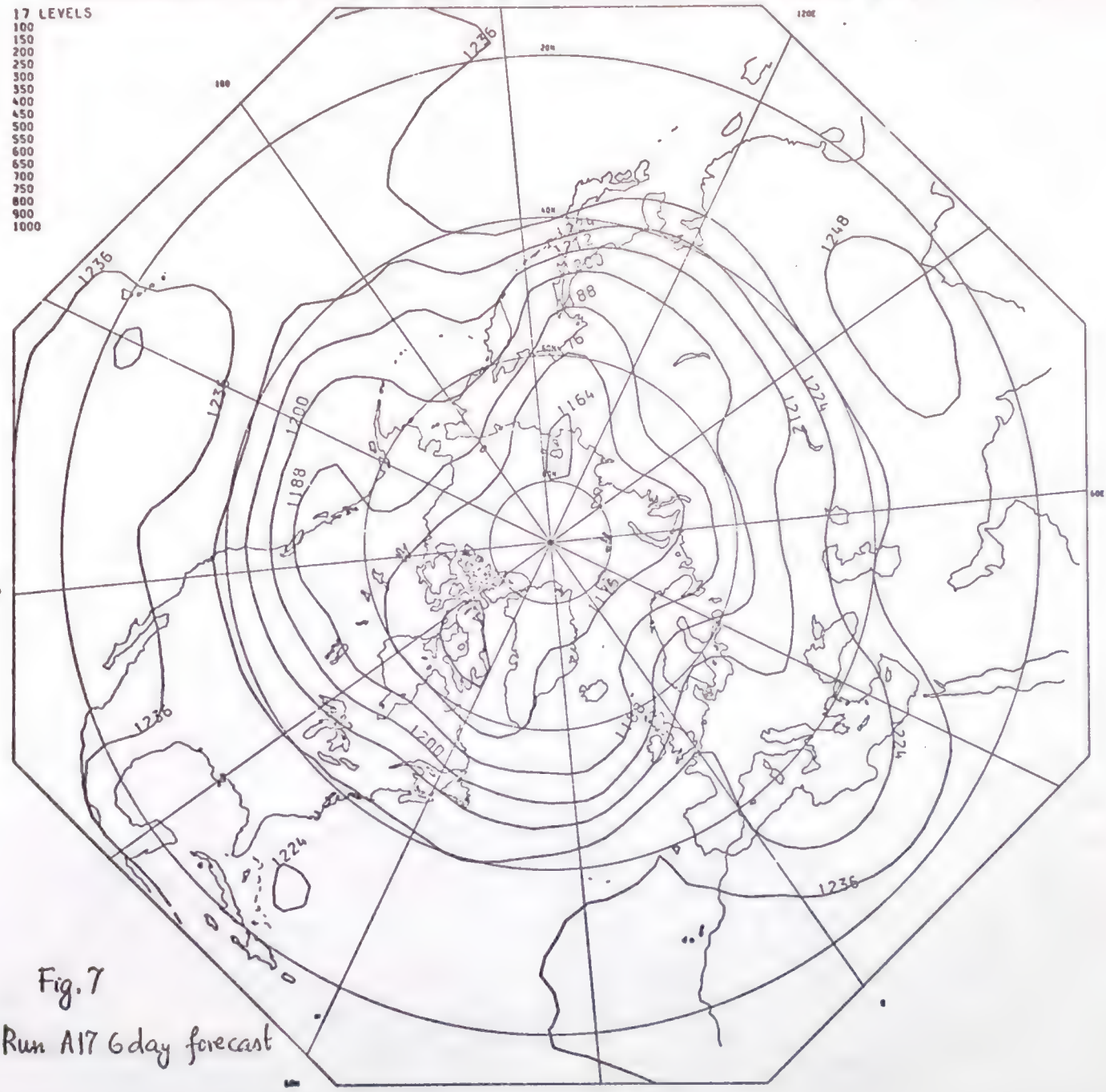
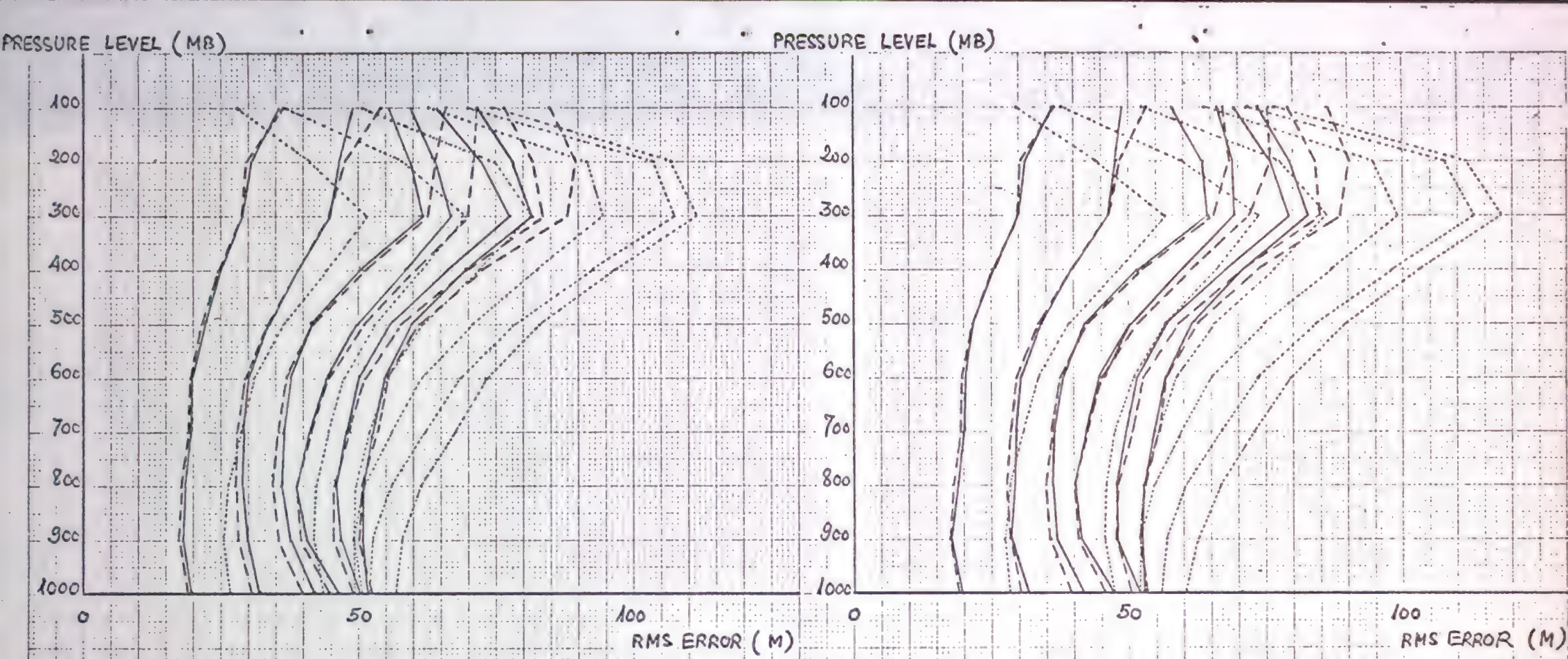


Fig. 7

Run A17 6 day forecast

300 KM OCTAGON



COMPLETE OCTAGON AREA

20×20 BRITISH ISLES AREA

RMS PERSISTENCE ERROR

RMS 10-LEVEL ERROR

RMS RUN A17 ERROR

FIG. 8 RMS ERROR DISTRIBUTION WITH PRESSURE LEVELS AND WITH FORECAST TIME

EXPERIMENTS	RUNS	NUMBER OF PRESSURE LEVELS	LIST OF PRESSURE LEVELS																	
A	A11	11	100	150	200	300	400	500	600	700	800	900	1000							
	A12	12	100	150	200	250	300	400	500	600	700	800	900	1000						
	A13	13	100	150	200	250	300	350	400	500	600	700	800	900	1000					
	A14	14	100	150	200	250	300	350	400	450	500	600	700	800	900	1000				
	A15	15	100	150	200	250	300	350	400	450	500	550	600	700	800	900	1000			
	A16	16	100	150	200	250	300	350	400	450	500	550	600	650	700	800	900	1000		
	A17	17	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	900	1000	
B	B11	11	100	200	300	400	500	550	600	700	800	900	1000							
	B13	13	100	200	300	400	450	500	550	600	650	700	800	900	1000					
	B15	15	100	200	300	350	400	450	500	550	600	650	700	750	800	900	1000			
	B17	17	100	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	1000	
C	C14	14	100	200	250	280	300	320	350	400	500	600	700	800	900	1000				

TABLE A

100 MB CONTOUR HEIGHT RMS ERROR (METRE)

EXPERIMENT	RUNS	COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
		T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	27.92	36.34	50.77	62.84	69.80	74.21	29.78	37.82	52.41	63.78	71.37	76.86
	10 LEVEL	36.47	53.95	66.17	71.54	76.71	84.85	36.25	53.21	67.18	75.52	79.15	86.20
A	A11	34.75	48.28	55.23	60.35	68.01	77.01	34.96	48.07	56.97	66.22	72.29	78.87
	A12	35.83	49.64	56.50	61.98	69.42	79.02	36.44	49.55	58.63	68.05	74.00	81.20
	A13	35.40	49.04	55.39	59.97	66.13	74.33	36.05	48.93	57.54	66.19	70.61	76.48
	A14	35.33	48.69	54.81	59.11	64.59	71.65	36.01	48.62	57.09	65.28	69.05	73.60
	A15	35.48	48.77	54.91	59.06	63.87	70.73	36.16	48.68	57.19	65.27	68.47	72.62
	A16	35.48	48.95	55.34	59.59	64.37	71.39	36.16	48.85	57.59	65.84	69.13	73.39
	A17	35.44	48.98	55.50	59.55	64.28	71.45	36.10	48.88	57.85	65.99	69.21	73.58
B	B11	37.80	55.16	67.43	72.44	76.28	84.24	37.82	54.65	68.54	76.92	78.99	85.27
	B13	36.99	53.91	66.06	70.79	74.29	81.57	36.93	53.32	67.18	75.45	77.14	82.61
	B15	35.76	52.61	64.53	69.68	72.85	79.40	35.60	51.84	65.49	74.09	75.56	80.36
	B17	35.32	52.57	64.12	68.88	72.69	79.93	35.26	51.93	65.11	73.49	75.86	81.53
C	C14	35.11	52.43	63.25	68.36	71.76	79.30	35.03	51.67	63.93	72.43	74.37	80.44

TABLE B.1

500MB CONTOUR HEIGHT RMS ERROR (METRE)

XPERIMENT	RUNS	COMPLETE OCTAGON AREA T+24	T+48	T+72	T+96	T+120	T+144	20x20 BRITISH ISLES AREA T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	41.23	58.14	74.83	91.58	103.86	106.92	44.05	59.82	77.63	94.59	107.62	111.59
	10 LEVEL	29.78	47.55	64.09	70.99	81.71	89.60	30.24	48.44	68.33	75.82	84.11	90.30
	A11	30.07	47.96	62.64	68.77	81.12	88.52	30.54	49.03	66.60	73.84	83.60	89.04
	A12	30.57	47.17	60.75	67.18	79.99	88.92	31.21	48.16	64.34	71.63	82.10	89.50
	A13	30.29	46.28	58.81	62.99	74.01	81.53	30.93	47.26	62.48	67.77	76.71	82.37
A	A14	30.33	46.02	58.64	63.22	73.26	79.66	31.02	47.11	62.61	68.02	76.08	80.48
	A15	30.48	46.13	58.77	63.15	72.40	78.37	31.15	47.19	62.74	68.06	75.44	79.32
	A16	30.49	46.35	59.31	63.57	72.29	78.24	31.14	47.37	63.27	68.54	75.54	79.32
	A17	30.47	46.47	59.48	63.81	72.53	78.12	31.10	47.48	63.49	68.90	75.95	79.33
	B11	32.40	50.20	66.93	73.33	82.40	88.71	32.92	51.09	70.81	78.18	85.04	89.31
B	B13	31.32	49.21	65.63	71.50	78.85	85.22	31.81	50.02	69.75	76.68	82.02	86.11
	B15	29.39	46.37	61.97	66.99	73.20	78.27	29.84	47.24	66.56	72.47	76.72	79.32
	B17	30.03	46.81	61.27	65.95	73.42	79.91	30.46	47.58	65.22	70.52	76.56	80.87
C	C14	29.94	46.19	59.00	63.59	71.42	78.39	30.36	46.89	62.60	67.59	74.08	79.15

TABLE B.2

300 MB CONTOUR HEIGHT RMS ERROR (METRE)

EXPERIMENT	RUNS	COMPLETE OCTAGON AREA T+24	T+48	T+72	T+96	T+120	T+144	20x20 BRITISH ISLES AREA T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	51.46	69.06	81.61	94.31	107.45	111.78	56.67	73.77	86.03	99.13	113.01	117.97
	10 LEVEL	28.97	44.87	62.78	70.15	83.46	87.90	29.94	46.32	65.64	72.04	84.78	88.84
A	A11	28.76	44.39	61.64	69.00	82.93	87.34	29.68	45.84	64.49	71.00	83.76	88.05
A	A12	29.04	45.02	62.66	70.98	85.78	91.24	29.91	46.46	65.22	72.73	86.42	91.43
A	A13	28.93	44.94	61.31	67.25	79.82	85.31	29.85	46.30	63.94	69.17	80.61	85.70
A	A14	28.95	44.93	61.34	67.32	79.18	83.89	29.92	46.39	64.27	69.35	80.20	84.48
A	A15	29.01	44.67	61.16	66.80	78.24	82.69	29.97	46.14	64.18	69.01	79.50	83.57
A	A16	29.03	44.84	61.35	66.79	77.60	81.87	29.99	46.29	64.40	69.11	79.08	82.95
A	A17	29.07	44.97	61.51	66.89	77.64	81.45	30.02	46.40	64.56	69.35	79.34	82.71
B	B11	30.52	45.97	63.76	71.03	83.39	86.51	31.45	47.37	66.50	73.14	84.82	87.54
B	B13	29.79	45.58	62.53	68.96	80.16	83.37	30.82	46.94	65.54	71.33	81.98	84.86
B	B15	29.42	45.68	62.47	68.18	78.44	81.15	30.45	47.07	65.75	70.81	80.56	82.84
B	B17	29.16	46.15	63.37	68.96	79.43	82.83	30.10	47.44	66.43	71.50	81.48	84.06
C	C14	28.37	44.68	60.27	66.06	75.94	80.64	29.32	45.94	62.98	67.78	77.45	81.49

TABLE B.3

400 MB CONTOUR HEIGHT RMS ERROR (METRE)

		COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
EXPERIMENT	RUNS	T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	44.25	61.66	72.12	82.41	92.50	96.49	48.34	66.17	76.37	86.93	98.06	103.12
	10 LEVEL	24.76	38.90	51.28	60.50	69.69	72.53	25.27	39.66	52.71	61.35	70.99	73.78
A	A11	24.47	38.31	50.23	59.90	69.51	72.56	24.94	39.04	51.71	60.70	70.32	73.51
	A12	24.36	38.38	50.48	60.85	71.03	75.00	24.82	39.12	51.77	61.53	71.57	75.34
	A13	24.93	39.05	50.45	59.34	68.30	72.76	25.46	39.71	51.71	60.01	68.94	73.25
	A14	24.86	39.04	50.34	59.02	67.55	71.46	25.42	39.78	51.82	59.83	68.47	72.36
	A15	24.91	38.82	50.13	58.37	66.68	70.47	25.47	39.59	51.70	59.35	67.80	71.75
	A16	24.97	38.94	50.23	58.46	66.22	69.80	25.53	39.69	51.83	59.51	67.48	71.29
	A17	25.01	39.02	50.26	58.52	66.22	69.41	25.58	39.77	51.83	59.68	67.65	71.08
B	B11	25.02	38.61	50.00	59.21	67.73	70.52	25.80	39.43	51.20	59.84	68.88	71.97
	B13	25.73	39.33	49.94	58.17	65.76	68.43	26.64	40.19	51.41	59.04	67.22	70.38
	B15	25.45	39.94	51.49	59.57	66.96	69.05	26.09	40.68	53.16	60.88	68.85	71.28
	B17	25.22	40.10	51.70	59.47	66.79	69.25	25.83	40.75	53.25	60.80	68.63	70.95
C	C14	24.96	39.51	50.91	58.94	66.16	69.57	25.55	40.18	52.31	59.82	67.66	70.70

TABLE B.4

500 MB CONTOUR HEIGHT RMS ERROR (METRE)

EXPERIMENT	RUNS	COMPLETE OCTAGON AREA T+24	T+48	T+72	T+96	T+120	T+144	20×20 BRITISH ISLES AREA T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	36.19	52.96	61.86	70.68	78.55	83.06	39.04	56.73	65.66	74.71	83.91	89.72
	10 LEVEL	21.45	33.28	41.78	50.99	57.83	61.06	21.82	33.61	42.47	51.60	59.06	62.65
A	A11	21.35	32.78	40.79	50.52	57.90	61.61	21.73	33.06	41.51	51.04	58.71	62.93
A	A12	21.15	32.54	40.57	50.65	58.15	62.79	21.56	32.83	41.19	51.02	58.61	63.45
A	A13	21.78	33.35	41.24	49.94	56.53	61.54	22.23	33.61	41.81	50.26	57.09	62.35
A	A14	21.85	33.55	41.28	50.01	56.46	61.01	22.31	33.84	41.93	50.48	57.31	62.28
A	A15	21.92	33.59	41.21	49.58	55.90	60.39	22.38	33.89	41.92	50.17	56.95	62.06
A	A16	22.00	33.70	41.38	49.81	55.78	60.03	22.46	33.98	42.10	50.45	56.91	61.87
A	A17	22.06	33.77	41.31	49.73	55.72	59.67	22.54	34.05	42.01	50.44	56.96	61.68
B	B11	21.90	33.39	41.46	50.47	56.54	60.47	22.69	33.90	42.09	51.00	57.82	62.46
B	B13	22.02	33.67	41.47	49.96	55.70	58.70	22.76	34.15	42.24	50.66	57.25	61.11
B	B15	22.40	34.63	42.66	50.79	56.54	59.16	22.89	34.96	43.45	51.70	58.27	61.78
B	B17	22.23	34.63	42.41	50.02	55.53	58.46	22.76	34.90	43.16	50.93	57.09	60.51
C	C14	22.03	33.93	42.02	49.78	55.34	59.19	22.47	34.21	42.68	50.36	56.62	60.63

TABLE B.5

500 MB CONTOUR HEIGHT RMS ERROR (METRE)

		COMPLETE OCTAGON AREA						20×20 BRITISH ISLES AREA					
XPERIMENT	RUNS	T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	31.15	47.31	55.28	61.45	68.35	73.20	33.57	51.04	58.80	65.17	73.45	79.46
	10 LEVEL	19.41	29.34	37.13	44.39	51.25	55.22	19.75	29.62	37.50	45.10	52.69	56.92
A	A11	19.34	28.88	36.56	44.33	51.81	56.19	19.65	29.12	36.95	44.98	52.97	57.72
	A12	19.18	28.66	36.33	44.27	51.72	56.89	19.53	28.92	36.65	44.73	52.47	57.69
	A13	19.72	29.41	37.17	44.07	50.59	56.04	20.05	29.63	37.41	44.43	51.35	56.92
	A14	19.85	29.74	37.40	44.07	50.46	55.54	20.17	29.94	37.65	44.54	51.46	56.86
	A15	19.92	29.95	37.39	43.75	50.10	54.99	20.24	30.15	37.68	44.29	51.27	56.63
	A16	20.04	30.16	37.87	44.27	50.27	54.97	20.36	30.36	38.14	44.85	51.48	56.77
	A17	20.06	30.17	37.71	44.05	50.21	54.74	20.42	30.35	37.97	44.66	51.51	56.67
B	B11	19.34	29.20	37.49	44.39	50.37	55.08	19.87	29.59	37.77	45.01	51.96	57.21
	B13	19.75	29.71	37.77	44.18	49.97	53.34	20.15	30.06	38.10	44.88	51.70	55.85
	B15	20.42	30.88	38.85	44.79	50.71	53.81	20.73	31.11	39.17	45.54	52.41	56.38
	B17	20.27	30.82	38.47	43.91	49.41	52.80	20.63	31.01	38.79	44.63	50.85	54.76
C	C14	20.16	30.07	37.94	43.71	49.43	53.39	20.41	30.27	38.17	44.20	50.58	54.66

TABLE B.6

700 MB CONTOUR HEIGHT RMS ERROR (METRE)

EXPERIMENT	RUNS	COMPLETE OCTAGON AREA T+24	T+48	T+72	T+96	T+120	T+144	20x20 BRITISH ISLES AREA T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	28.70	44.60	52.16	56.04	62.12	67.47	30.90	48.42	55.46	59.60	67.00	73.29
	10 LEVEL	19.19	28.21	35.67	41.51	48.76	53.32	19.54	28.62	36.04	42.53	50.70	55.43
A	A11	19.13	27.93	35.25	41.45	49.40	54.24	19.50	28.32	35.71	42.54	51.26	56.35
	A12	18.98	27.73	34.99	41.25	49.24	54.67	19.39	28.17	35.41	42.16	50.68	56.00
	A13	19.43	28.43	35.81	41.19	48.32	53.90	19.81	28.83	36.16	41.96	49.64	55.23
	A14	19.58	28.77	35.99	41.05	48.13	53.32	19.95	29.13	36.29	41.89	49.64	55.01
	A15	19.72	29.08	36.12	40.88	47.92	53.12	20.08	29.44	36.43	41.76	49.56	55.04
	A16	19.76	29.21	36.56	41.35	47.96	52.74	20.10	29.55	36.85	42.21	49.59	54.74
	A17	19.82	29.24	36.45	41.10	48.01	52.80	20.19	29.57	36.73	41.99	49.71	54.89
B	B11	19.17	28.23	36.37	41.53	48.19	53.65	19.62	28.75	36.64	42.49	50.27	56.13
	B13	19.47	28.61	36.35	41.09	47.56	51.19	19.93	29.03	36.67	42.06	49.65	53.93
	B15	20.06	29.71	37.28	41.48	48.10	51.73	20.38	30.06	37.56	42.45	50.12	54.48
	B17	19.98	29.63	36.95	40.61	46.81	50.57	20.36	29.98	37.25	41.53	48.51	52.74
C	C14	19.76	28.90	36.35	40.58	47.01	51.12	20.05	29.25	36.58	41.29	48.37	52.60

TABLE B.7

800 MB CONTOUR HEIGHT RMS ERROR (METRE)

EXPERIMENT	RUNS	COMPLETE OCTAGON AREA T+24	T+48	T+72	T+96	T+120	T+144	20x20 BRITISH ISLES AREA T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	26.32	42.36	49.74	51.14	55.93	61.49	28.33	46.09	52.74	54.45	60.44	66.83
	10 LEVEL	17.94	27.67	34.54	38.87	45.82	50.73	18.26	27.99	34.95	40.22	48.12	53.08
A	A11	17.90	27.50	34.33	39.09	46.84	51.91	18.30	27.88	34.90	40.59	49.14	54.36
A	A12	17.75	27.47	34.21	39.20	46.95	52.51	18.17	27.90	34.82	40.48	48.82	54.13
A	A13	18.15	28.09	35.06	39.28	46.19	51.78	18.52	28.46	35.50	40.33	47.81	53.26
A	A14	18.36	28.45	35.25	39.00	46.03	51.14	18.71	28.76	35.61	40.08	47.74	52.89
A	A15	18.57	28.82	35.46	38.99	45.89	51.22	18.90	29.10	35.78	40.03	47.67	53.08
A	A16	18.64	29.06	36.06	39.44	45.92	50.70	18.96	29.31	36.34	40.46	47.70	52.69
A	A17	18.71	29.09	35.98	39.15	45.98	50.95	19.04	29.34	36.24	40.21	47.82	52.99
B	B11	17.94	27.83	35.56	39.24	45.53	51.26	18.32	28.18	35.85	40.48	47.86	53.84
B	B13	18.39	28.27	35.64	39.03	45.22	48.94	18.68	28.55	35.91	40.19	47.47	51.71
B	B15	18.85	29.30	36.53	39.30	45.62	49.58	19.11	29.51	36.73	40.39	47.74	52.29
B	B17	18.84	29.35	36.39	38.55	44.73	48.72	19.15	29.57	36.60	39.58	46.47	50.84
C	C14	18.53	28.52	35.65	38.60	44.87	48.85	18.76	28.75	35.84	39.42	46.19	50.22

TABLE B.8

00 MB CONTOUR HEIGHT RMS ERROR (METRE)

PERIMENT	RUNS	COMPLETE OCTAGON AREA T+24	T+48	T+72	T+96	T+120	T+144	20x20 BRITISH ISLES AREA T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	25.53	42.11	49.35	48.97	52.69	58.15	27.41	45.79	52.02	52.02	56.90	62.78
	10 LEVEL	17.37	28.24	35.59	39.56	45.60	50.08	17.55	28.35	35.85	40.83	47.80	51.97
	A11	17.22	27.95	35.37	39.73	46.72	51.38	17.51	28.16	35.83	41.19	48.94	53.44
	A12	17.12	28.08	35.56	40.33	47.28	52.42	17.40	28.32	36.00	41.56	49.07	53.70
	A13	17.54	28.63	36.34	40.66	46.83	51.98	17.76	28.79	36.63	41.57	48.28	52.99
A	A14	17.82	29.13	36.64	40.43	46.75	51.27	18.01	29.21	36.85	41.31	48.17	52.42
	A15	18.06	29.54	36.98	40.62	46.77	51.62	18.23	29.59	37.13	41.43	48.22	52.80
	A16	18.13	29.82	37.59	40.99	46.82	50.93	18.29	29.84	37.71	41.76	48.24	52.23
	A17	18.20	29.90	37.48	40.62	46.81	51.30	18.37	29.91	37.58	41.46	48.26	52.62
	B11	17.48	28.49	36.87	40.20	45.54	50.54	17.65	28.59	37.02	41.33	47.68	52.54
B	B13	18.00	29.03	37.10	40.41	45.78	48.59	18.11	29.07	37.21	41.36	47.67	50.68
	B15	18.33	30.00	37.90	40.67	46.10	49.32	18.43	29.98	37.93	41.55	47.83	51.31
	B17	18.34	30.10	37.90	40.22	45.67	49.01	18.48	30.09	37.96	41.02	47.02	50.46
C	C14	18.13	29.22	37.09	40.20	45.79	49.01	18.18	29.21	37.12	40.82	46.79	49.78

TABLE B.9

1000 MB CONTOUR HEIGHT RMS ERROR (METRE)

EXPERIMENT	RUNS	COMPLETE OCTAGON AREA T+24	T+48	T+72	T+96	T+120	T+144	20×20 BRITISH ISLES AREA T+24	T+48	T+72	T+96	T+120	T+144
	PERSISTENCE	26.41	43.62	50.53	49.25	52.13	56.90	28.22	47.26	52.91	52.14	56.10	60.71
	10 LEVEL	19.11	30.77	39.77	44.79	49.06	52.58	19.02	30.58	39.61	45.49	50.62	53.39
A	A11	18.76	30.37	39.48	44.84	50.00	53.75	18.77	30.28	39.52	45.66	51.56	54.73
	A12	18.71	30.54	39.92	45.76	50.91	55.69	18.76	30.45	39.92	46.37	52.09	55.45
	A13	19.11	31.02	40.66	46.39	50.93	55.16	19.04	30.86	40.54	46.68	51.75	55.20
	A14	19.44	31.75	41.12	46.43	51.06	54.58	19.34	31.51	40.93	46.69	51.80	54.72
	A15	19.69	32.22	41.67	46.94	51.29	55.10	19.59	31.95	41.43	47.11	52.01	55.21
	A16	19.71	32.54	42.32	47.31	51.65	54.43	19.62	32.26	42.04	47.45	52.33	54.64
	A17	19.89	32.73	42.21	46.97	51.63	54.93	19.80	32.43	41.91	47.18	52.27	55.12
B	B11	19.42	31.24	41.34	45.83	49.43	52.96	19.30	31.04	41.08	46.36	50.86	53.81
	B13	19.86	31.92	41.83	46.63	50.40	51.67	19.73	31.69	41.52	46.97	51.49	52.50
	B15	20.05	32.84	42.55	46.90	50.73	52.49	19.92	32.54	42.18	47.20	51.62	53.21
	B17	20.19	32.97	42.58	46.65	50.51	52.56	20.06	32.65	42.23	46.88	51.14	52.92
C	C14	19.93	31.92	41.66	46.44	50.48	52.65	19.71	31.60	41.29	46.54	50.89	52.47

TABLE B.10

500 MB RMS ERROR DIFFERENCE BETWEEN 10-LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

EXPERIMENT	RUNS	COMPLETE OCTAGON AREA T+24	T+48	T+72	T+96	T+120	T+144	20x20 BRITISH ISLES AREA T+24	T+48	T+72	T+96	T+120	T+144
A	A11	1.72	5.67	10.94	11.19	8.73	7.84	1.29	5.14	10.21	9.30	6.86	7.33
	A12	0.64	4.31	9.67	9.56	7.32	5.83	- 0.19	3.66	8.55	7.47	5.15	5.00
	A13	1.07	4.91	10.78	11.57	10.61	10.52	0.20	4.28	9.64	9.33	8.54	9.72
	A14	1.14	5.26	11.36	12.43	12.15	13.20	0.24	4.59	10.09	10.24	10.10	12.60
	A15	0.99	5.18	11.26	12.48	12.87	14.12	0.09	4.53	9.99	10.25	10.68	13.58
	A16	0.99	5.00	10.83	11.95	12.37	13.46	0.09	4.36	9.59	9.68	10.02	12.81
	A17	1.03	4.97	10.67	11.99	12.46	13.40	0.15	4.33	9.33	9.53	9.94	12.62
B	B11	- 1.33	- 1.21	- 1.26	- 0.90	0.46	0.61	- 1.57	- 1.44	- 1.36	- 1.40	0.16	0.93
	B13	- 0.52	0.04	0.11	0.75	2.45	3.28	- 0.68	- 0.11	0.00	0.07	2.01	3.59
	B15	0.71	1.34	1.64	1.86	3.89	5.45	0.65	1.37	1.69	1.43	3.59	5.84
	B17	1.15	1.38	2.05	2.66	4.05	4.92	0.99	1.28	2.07	2.03	3.29	4.67
C	C14	1.36	1.52	2.92	3.18	4.98	5.55	1.22	1.54	3.25	3.09	4.78	5.76

TABLE C.1

200 MB RMS ERROR DIFFERENCE BETWEEN 10 LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

		COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
EXPERIMENT	RUNS	T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
A	A11	-0.29	-0.41	1.45	2.22	0.59	1.08	-0.30	-0.59	1.73	1.93	0.51	1.26
	A12	-0.79	0.38	3.34	3.81	1.72	0.68	-0.97	0.28	3.19	4.19	1.71	0.80
	A13	-0.51	1.27	5.28	8.00	7.70	8.07	-0.69	0.18	5.85	8.05	7.40	7.93
	A14	-0.55	1.53	5.45	7.77	8.45	9.94	-0.78	1.38	5.72	7.80	8.05	9.82
	A15	-0.70	4.42	5.32	7.84	9.31	11.23	-0.91	1.25	5.59	7.76	8.67	10.98
	A16	-0.71	1.20	4.78	7.42	9.42	11.36	-0.90	1.07	5.06	7.28	8.57	10.98
	A17	-0.69	1.08	4.61	7.18	9.18	11.48	-0.86	0.96	4.84	6.92	8.16	10.97
B	B11	-2.62	-2.65	-2.84	-2.34	-0.69	0.89	-2.68	-2.65	-2.48	-2.36	-0.93	0.99
	B13	-1.54	-1.66	-1.54	-0.51	2.86	4.38	-1.57	-1.58	-1.42	-0.36	2.09	4.19
	B15	0.39	1.18	2.12	4.00	8.51	11.33	0.40	1.20	1.77	3.35	7.39	10.98
	B17	-0.25	0.74	2.82	5.04	8.29	9.69	-0.22	0.86	3.11	5.30	7.55	9.43
C	C14	-0.16	1.36	5.09	7.40	10.29	11.21	-0.12	1.55	5.73	8.23	10.03	11.15

TABLE C.2

300 MB RMS ERROR DIFFERENCE BETWEEN 10 LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

		COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
XPERIMENT	RUNS	T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
A	A11	0·21	0·48	1·14	1·15	0·53	0·56	0·26	0·48	1·15	1·04	1·02	0·79
	A12	−0·07	−0·15	0·12	−0·83	−2·32	−3·34	0·03	−0·14	0·42	−0·69	−1·64	−2·59
	A13	0·04	−0·07	1·47	2·90	3·64	2·59	0·09	0·02	1·70	2·87	4·17	3·14
	A14	0·02	−0·06	1·44	2·83	4·28	4·01	0·02	−0·07	1·37	2·69	4·58	4·36
	A15	−0·04	0·20	1·62	3·35	5·22	5·21	−0·03	0·18	1·46	3·03	5·28	5·27
	A16	−0·06	0·03	1·43	3·36	5·86	6·03	−0·05	0·03	1·24	2·93	5·70	5·89
	A17	−0·10	−0·10	1·27	3·26	5·82	6·45	−0·08	−0·08	1·08	2·69	5·44	6·13
B	B11	−1·55	−1·10	−0·98	−0·88	0·07	1·39	−1·51	−1·05	−0·86	−1·10	−0·04	1·30
	B13	−0·82	−0·71	0·25	1·19	3·30	4·53	−0·88	−0·62	0·10	0·71	2·80	3·98
	B15	−0·45	−0·81	0·31	1·97	5·02	6·75	−0·51	−0·75	−0·11	1·23	4·22	6·00
	B17	−0·19	−1·28	−0·59	1·19	4·03	5·07	−0·16	−1·12	−0·79	0·54	3·30	4·78
C	C14	0·60	0·19	2·51	4·09	7·52	7·26	0·62	0·38	2·66	4·26	7·33	7·35

TABLE C.3

500 MB RMS ERROR DIFFERENCE BETWEEN 10 LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

		COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
EXPERIMENT	RUNS	T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
A	A11	0·29	0·59	1·05	0·60	0·18	−0·03	0·33	0·62	1·00	0·65	0·67	0·27
	A12	0·40	0·52	0·80	−0·35	−1·34	−2·47	0·45	0·54	0·94	−0·18	−0·58	−1·56
	A13	−0·17	−0·15	0·83	1·16	1·39	−0·23	−0·19	−0·05	1·00	1·34	2·05	0·53
	A14	−0·10	−0·14	0·94	1·48	2·14	1·07	−0·15	−0·12	0·89	1·52	2·52	1·42
	A15	−0·15	0·08	1·15	2·13	3·01	2·06	−0·20	0·07	1·01	2·00	3·19	2·03
	A16	−0·21	−0·04	1·05	2·04	3·47	2·73	−0·26	−0·03	0·88	1·84	3·51	2·49
	A17	−0·25	−0·12	1·02	1·98	3·47	3·12	−0·31	−0·11	0·88	1·67	3·34	2·70
B	B11	−0·26	0·29	1·28	1·29	1·96	2·01	−0·53	0·23	1·51	1·51	2·11	1·81
	B13	−0·97	−0·43	1·34	2·33	3·93	4·10	−1·37	−0·53	1·27	2·31	3·77	3·40
	B15	−0·69	−0·04	−0·21	0·93	2·73	3·48	−0·82	−1·02	−0·45	0·47	2·14	2·50
	B17	−0·46	−1·20	−0·42	1·03	2·90	3·28	−0·56	−1·09	−0·54	0·55	2·36	2·83
C	C14	−0·20	−0·61	0·37	1·56	3·53	2·96	−0·28	−0·52	0·40	1·53	3·33	3·08

TABLE C.4

500 MB RMS ERROR DIFFERENCE BETWEEN 10-LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

		COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
EXPERIMENT	RUNS	T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
A	A11	0·10	0·50	0·99	0·47	−0·07	−0·55	0·09	0·55	0·96	0·56	0·35	−0·28
	A12	0·30	0·74	1·21	0·34	−0·32	−1·73	0·26	0·78	1·28	0·58	0·45	−0·80
	A13	−0·33	−0·07	0·54	1·05	1·30	−0·48	−0·41	0·00	0·66	1·34	1·97	0·30
	A14	−0·40	−0·27	0·50	0·98	1·37	0·05	−0·49	−0·23	0·54	1·12	1·75	0·37
	A15	−0·47	−0·31	0·57	1·41	1·93	0·67	−0·56	−0·28	0·55	1·43	2·11	0·59
	A16	−0·55	−0·42	0·40	1·18	2·05	1·03	−0·64	−0·37	0·37	1·15	2·15	0·78
	A17	−0·61	−0·49	0·47	1·26	2·11	1·39	−0·72	−0·44	0·46	1·16	2·10	0·97
B	B11	−0·45	−0·11	0·32	0·52	1·29	0·59	−0·87	−0·29	0·38	0·60	1·24	0·19
	B13	−0·57	−0·39	0·31	1·03	2·13	2·36	−0·94	−0·54	0·23	0·94	1·81	1·54
	B15	−0·95	−1·35	−0·88	0·20	1·29	1·90	−1·07	−1·35	−0·98	−0·10	0·79	0·87
	B17	−0·78	−1·35	−0·63	0·97	2·30	2·60	−0·94	−1·29	−0·69	0·67	1·97	2·14
C	C14	−0·58	−0·65	−0·24	1·21	2·49	1·87	−0·65	−0·60	−0·21	1·24	2·67	2·02

TABLE C.5

500 MB RMS ERROR DIFFERENCE BETWEEN 10 LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

		COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
XPERIMENT	RUNS	T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
A	A11	0·07	0·46	0·57	0·06	-0·56	-0·97	0·10	0·50	0·55	0·12	-0·28	-0·80
	A12	0·23	0·68	0·80	0·12	-0·47	-1·67	0·22	0·70	0·85	0·37	0·22	-0·77
	A13	-0·31	-0·07	-0·04	0·32	0·66	-0·82	-0·30	-0·01	0·09	0·67	1·34	0·00
	A14	-0·44	-0·40	-0·27	0·32	0·79	-0·32	-0·42	-0·32	-0·15	0·56	1·23	0·06
	A15	-0·51	-0·61	-0·26	0·64	1·15	0·23	-0·49	-0·53	-0·18	0·81	1·42	0·29
	A16	-0·63	-0·82	-0·74	0·12	0·98	0·25	-0·61	-0·74	-0·64	0·25	1·21	0·15
	A17	-0·65	-0·83	-0·58	0·34	1·04	0·48	-0·67	-0·73	-0·47	0·44	1·18	0·25
B	B11	0·07	0·14	-0·36	0·00	0·88	0·14	-0·12	+0·03	-0·27	0·09	0·73	-0·29
	B13	-0·34	-0·37	-0·64	0·21	1·28	1·88	-0·40	-0·44	-0·60	0·22	0·99	1·07
	B15	-1·01	-1·54	-1·72	-0·40	0·54	1·41	-0·98	-1·49	-1·67	-0·44	0·28	0·54
	B17	-0·86	-1·48	-1·34	0·48	1·84	2·42	-0·88	-1·39	-1·29	0·47	1·84	2·16
C	C14	-0·75	-0·73	-0·81	0·68	1·82	1·83	-0·66	-0·65	-0·67	0·90	2·11	2·26

TABLE C.6

700 MB RMS ERROR DIFFERENCE BETWEEN 10-LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

XPERIMENT	RUNS	COMPLETE OCTAGON AREA T+24	T+48	T+72	T+96	T+120	T+144	20x20 BRITISH ISLES AREA T+24	T+48	T+72	T+96	T+120	T+144
A	A11	0·06	0·28	0·42	0·06	-0·64	-0·92	0·04	0·30	0·33	-0·01	-0·56	-0·92
	A12	0·21	0·48	0·68	0·26	-0·48	-1·35	0·15	0·45	0·60	0·37	0·02	-0·57
	A13	-0·24	-0·22	-0·14	0·32	0·44	-0·58	-0·27	-0·21	-0·12	0·57	1·06	0·20
	A14	-0·39	-0·56	-0·32	0·46	0·63	0·00	-0·41	-0·51	-0·25	0·64	1·06	0·42
	A15	-0·53	-0·87	-0·45	0·63	0·84	0·20	-0·54	-0·82	-0·39	0·77	1·14	0·39
	A16	-0·57	-1·00	-0·89	0·16	0·80	0·58	-0·56	-0·93	-0·81	0·32	1·11	0·69
	A17	-0·63	-1·03	-0·78	0·41	0·75	0·52	-0·65	-0·95	-0·69	0·54	0·99	0·54
B	B11	0·02	-0·07	-0·70	-0·02	0·57	-0·33	-0·08	-0·13	-0·60	0·04	0·43	-0·70
	B13	-0·28	-0·40	-0·68	0·42	1·20	2·13	-0·29	-0·41	-0·63	0·47	1·05	1·50
	B15	-0.87	-1.50	-1.61	0.03	0.66	1.59	-0.84	-1.44	-1.52	0.08	0.58	0.95
	B17	-0.79	-1.42	-1.28	0.90	1.95	2.75	-0.82	-1.36	-1.21	1.00	2.19	2.69
C	C14	-0.57	-0.69	-0.68	0.93	1.75	2.20	-0.51	-0.63	-0.54	1.24	2.33	2.83

TABLE C.7

800 MB RMS ERROR DIFFERENCE BETWEEN 10-LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

EXPERIMENT	RUNS	COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
		T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
A	A11	0·04	0·17	0·21	-0·22	-1·02	-1·18	-0·04	0·11	0·05	-0·37	-1·02	-1·28
	A12	0·19	0·20	0·30	-0·33	-1·13	-1·78	0·09	0·09	0·13	-0·26	-0·70	-1·05
	A13	-0·21	-0·42	-0·52	-0·41	-0·37	-1·05	-0·26	-0·47	-0·55	-0·11	0·31	-0·18
	A14	-0·42	-0·78	-0·71	-0·13	-0·21	-0·41	-0·45	-0·77	-0·66	0·14	0·38	0·19
	A15	-0·63	-1·15	-0·92	-0·12	-0·07	-0·49	-0·64	-1·11	-0·83	0·19	0·45	0·00
	A16	-0·70	-1·39	-1·52	-0·57	-0·10	0·03	-0·70	-1·32	-1·39	-0·24	0·42	0·39
	A17	-0·77	-1·42	-1·44	-0·28	-0·16	-0·22	-0·78	-1·35	-1·29	0·01	0·30	0·09
B	B11	0·00	-0·16	-1·02	-0·37	0·29	-0·53	-0·06	-0·19	-0·90	-0·26	0·26	-0·76
	B13	-0·45	-0·60	-1·10	-0·16	0·60	1·79	-0·42	-0·56	-0·96	0·03	0·65	1·37
	B15	-0·91	-1·63	-1·99	-0·43	0·20	1·15	-0·85	-1·52	-1·78	-0·17	0·38	0·79
	B17	-0·90	-1·68	-1·85	0·32	1·09	2·01	-0·89	-1·58	-1·65	0·64	1·65	2·24
C	C14	-0·59	-0·85	-1·11	0·27	0·95	1·88	-0·50	-0·76	-0·89	0·80	1·93	2·86

TABLE C.8

300 MB RMS ERROR DIFFERENCE BETWEEN 10-LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

		COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
PERIMENT	RUNS	T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
A	A11	0·15	0·29	0·22	-0·17	-1·12	-1·30	0·04	0·19	0·02	-0·36	-1·14	-1·47
	A12	0·25	0·16	0·03	-0·77	-1·68	-2·34	0·15	0·03	-0·15	-0·73	-1·27	-1·73
	A13	-0·17	-0·39	-075	-1·10	-1·23	-1·90	-0·21	-0·44	-0·78	-0·74	-0·48	-1·02
	A14	-0·45	-0·89	-1·05	-0·87	-1·15	-1·19	-0·46	-0·86	-1·00	-0·48	-0·37	-0·45
	A15	-0·69	-1·30	-1·39	-1·06	-1·17	-1·54	-0·68	-1·24	-1·28	-0·60	-0·42	-0·83
	A16	-0·76	-1·58	-2·00	-1·43	-1·22	-0·85	-0·74	-1·49	-1·86	-0·93	-0·44	-0·26
	A17	-0·83	-1·66	-1·89	-1·06	-1·21	-1·22	-0·82	-1·56	-1·73	-0·63	-0·46	-0·65
B	B11	-0·11	-0·25	-1·28	-0·64	0·06	-0·46	-0·10	-0·24	-1·17	-0·50	0·12	-0·57
	B13	-0·63	-0·79	-2·51	-0·85	-0·18	1·49	-0·56	-0·72	-1·36	-0·53	0·13	1·29
	B15	-0·96	-1·76	-2·31	-1·11	-0·50	0·76	-0·88	-1·63	-2·08	-0·72	-0·03	0·66
	B17	-0·97	-1·86	-2·31	-0·66	-0·07	1·07	-0·93	-1·74	-2·11	-0·19	0·78	1·51
C	C14	-0·76	-0·98	-1·50	-0·64	-0·19	1·07	-0·63	-0·86	-1·27	0·01	1·01	2·19

TABLE C.9

500 MB RMS ERROR DIFFERENCE BETWEEN 10 LEVEL AND VARIABLE LEVEL FORECASTS (METRE)

		COMPLETE OCTAGON AREA						20x20 BRITISH ISLES AREA					
PERIMENT	RUNS	T+24	T+48	T+72	T+96	T+120	T+144	T+24	T+48	T+72	T+96	T+120	T+144
A	A11	0·35	0·40	0·29	-0·05	-0·94	-1·17	0·25	0·30	0·09	-0·17	-0·94	-1·34
	A12	0·40	0·23	-0·15	-0·97	-1·85	-2·51	0·32	0·13	-0·31	-0·88	-1·47	-2·06
	A13	0·09	-0·25	-0·89	-1·60	-1·87	-2·58	-0·02	-0·28	-0·93	-1·19	-1·13	-1·81
	A14	-0·33	-0·98	-1·35	-1·64	-2·00	-2·00	-0·32	-0·93	-1·32	-1·20	-1·18	-1·33
	A15	-0·58	-1·45	-1·90	-2·15	-2·23	-2·52	-0·57	-1·37	-1·82	-1·62	-1·39	-1·82
	A16	-0·60	-1·77	-2·55	-2·52	-2·59	-1·85	-0·60	-1·68	-2·43	-1·96	-1·71	-1·25
	A17	-0·78	-1·96	-2·44	-2·18	-2·57	-2·35	-0·78	-1·85	-2·30	-1·69	-1·65	-1·73
B	B11	-0·31	-0·47	-1·57	-1·04	-0·37	-0·38	-0·28	-0·46	-1·47	-0·87	-0·24	-0·42
	B13	-0·75	-1·15	-2·06	-1·84	-1·34	0·91	-0·71	-1·11	-1·91	-1·48	-0·87	0·89
	B15	-0·94	-2·07	-2·78	-2·11	-1·67	0·09	-0·90	-1·96	-2·57	-1·71	-1·00	0·18
	B17	-1·08	-2·20	-2·81	-1·86	-1·45	0·02	-1·04	-2·07	-2·62	-1·39	-0·52	0·47
C	C14	-0·82	-1·15	-1·89	-1·65	-1·42	-0·07	-0·69	-1·02	-1·68	-1·05	-0·27	0·92

TABLE C.10